

einer günstigen Bodenzusammensetzung). Die Baue bleiben kaum länger als ein halbes Jahr unbewohnt und Tierleichen müssen wegen Raumnot – meist bald nach der Zersetzung – entfernt werden.

Die Feststellung, die hohe Mortalität der Jungdachse in den ersten Lebenswochen (bis 25 %) sei durch das stickige Bauklima verursacht (NEAL und HARRISON 1958; STUBBE 1965), kann nur für solche Baue zutreffen, deren über die Maßen feuchtes Baumilieu durch eine hohe Wasserhaltefähigkeit und mangelhafte Drainage des Bodens bei schlechter Belüftung verursacht wird. In erster Linie sind dies Böden mit einem geringen Sandanteil. Baue mit diesen Eigenschaften sind als suboptimal zu werten. Auch wenn einige davon im Laufe der Jahre Ausmaße erreichen, die an die Größe von optimalen Sandbauen heranreichen, so sind hier große Baue im Vergleich zur Häufigkeit großer Baue in Sandböden selten.

Danksagung

Diese Untersuchung wurde z.T. durch Mittel des Bayerischen Staatsministeriums für Landesentwicklung und Umweltfragen finanziert. Herrn Dr. H. H. BECHER vom Lehrstuhl für Bodenkunde der TU München danke ich für die Analyse der Bodenproben und Herrn E. LANGENSCHIEDT von der Nationalparkverwaltung Berchtesgaden für geologische Auskünfte im Gelände. Den Herren Dr. W. ARNOLD und Dr. F. TRILLMICH vom Max-Planck-Institut für Verhaltensphysiologie Seewiesen bin ich für kritische Durchsicht des Manuskripts dankbar.

Zusammenfassung

In zwei Untersuchungsgebieten Südostbayerns wurden 148 Dachsbau hinsichtlich ihrer Eignung zur Bauanlage untersucht.

Die Baugröße wurde getrennt nach Erd- und Felsbauen ermittelt. Anhand des vor den Bauen liegenden Erdauswurfmaterials wurde die Grabbarkeit des Bodens in vier Grabbarkeitsklassen eingeteilt, worin sich die beiden Untersuchungsgebiete signifikant unterscheiden ($\chi^2 = 69,507$, $p < 0,001$).

Von 30 Erdbauen wurden Bodenanalysen durchgeführt, wobei u.a. die Körnung, die Bodenart und die Bonitierung des Bodens analysiert wurden. Nach dieser Bodenanalyse, mit deren Hilfe auch die anderen restlichen Böden zugeordnet werden konnten, wurden diese Böden in vier „Qualitätsstufen“ eingeteilt und diese mit der Baugröße in Beziehung gebracht. Daraus ergibt sich klar, daß die Dachse Sandböden vor allen anderen Böden bevorzugen ($\chi^2 = 36,86$, $p < 0,001$) und hier auch die größten Baue anlegen (H-Test, $p < 0,001$). Zum Graben eines Dachsbau eignet sich ein Boden von ungefähr der folgenden Körnung am besten: bis 10 % Tonanteile, 15 % Schluff und ca. 75 % Sand.

Die Typen der Felsbaue und ihre Funktion werden bewertet und die ermittelten Befunde diskutiert. Die Daten sind mit der eingangs aufgestellten Hypothese, daß die unterschiedlichen Baugrößen beider Untersuchungsgebiete auf „Qualitätsunterschiede“ der Böden zurückzuführen sind, verträglich.

Literatur

- Bayerisches Geologisches Landesamt (Hrsg.) (1981): Geologische Karte von Bayern 1:500 000. München. pp. 5–168.
- Bundesanstalt für Geowissenschaften und Rohstoffe und den geol. Landesämtern in der Bundesrepublik Deutschland (Hrsg.) (1982): Bodenkundliche Kartieranleitung. 3. Aufl. Hannover.
- BOCK, W. F. (1986): Kriterien zur Größenbeurteilung der Baue des Dachses *Meles meles* L. Säugetierkundl. Mitt. 33, 227–234.
- CLEMENTS, E. D. (1974): National badger survey in Sussex. Sussex Trust for Nat. Cons., Mamm. Report. for 1970/71.
- DUNWELL, M. R.; KILLINGLEY, A. (1969): The distribution of badger sets in relation to the geology of the Chilterns. J. Zool. 158, 204–208.
- GOETHE, F. (1955): Die Säugetiere des Teutoburgerwaldes und des Lipperlandes. Abh. Landesmus. Naturk. Münster 17, 5–195.
- HARRIS, S. (1984): Ecology of urban badgers *Meles meles*. Distribution in Britain and habitat selection, persecution, food and damage in the city of Bristol. Biological Conservatum 28, 349–375.

- HEPTNER, V. G.; NAUMOV, N. P. (Hrsg.) (1974): Die Säugetiere der Sowjetunion. Bd. II: Seekühe und Raubtiere. Jena: VEB G. Fischer.
- KRUUK, H. (1978): Spatial organization and territorial behaviour of the European badger *Meles meles*. J. Zool. (Lond.) 184, 1-19.
- LIKHACHEV, G. N. (1956): Some ecological traits of the badger of the Tula abatis Broadleaf Forests. Studies on mammals in Government Preserves. Ed. by YURGENSON. Moscow: Ministry of Agriculture of the USSR.
- LUGERT, J. (1985): Untersuchungen zur Bestandsentwicklung und Situation des Dachses (*Meles meles* Linne, 1758) in Schleswig-Holstein. Dipl.-Arbeit Univ. Kiel, Forschungsstelle Wildbiologie.
- NEAL, E. G.; HARRISON, R. J. (1958): Reproduction in the European Badgers (*Meles meles*). Trans. Zool. Soc. Lond. 29, 67-131.
- NEAL, E. (1972): The national badger survey. Mammal Rev. 2, 55-64.
- NEAL, E. G. (1977): Badgers. Poole: Dorset: Blandford Press.
- STUBBE, M. (1982): Schutz und Hege des Dachses. In: Buch der Hege. Hrsg. von H. STUBBE. Berlin: VEB Deutscher Landwirtschaftsverlag, pp. 294-317.
- WIJNGAARDEN, A. VAN; PEPPEL, J. VAN DE (1964): The badger *Meles meles* (L.), in the Netherlands. Lutra 6, 1-60.

Anschrift des Verfassers: Dr. WALTER FRIEDRICH BOCK, Institut für Haustierkunde, Universität Kiel, Olshausenstr. 40-60, D-2300 Kiel

Scent marking behaviour in captive Water mongooses (*Atilax paludinosus*)

By CAROLYN M. BAKER

Department of Biology, Natal University, Durban

Receipt of Ms. 1. 7. 1987

Abstract

Scent marking in captive *Atilax paludinosus* is described. The four methods recorded include defaecation, urination, anal marking and cheek rubbing. Anal marking was most frequently used and in females the frequency was significantly higher during the non-breeding season. Sexual dimorphism with respect to anal marking was exhibited, females marking more frequently than males. Cheek rubbing frequency was higher in the presence of conspecifics and females showed a significant increase in cheek marking during the breeding season. Defaecation rates varied with food intake, while urination frequencies were significantly higher when mongooses shared an enclosure with a conspecific. The relevance of the different rates and patterns of marking are discussed in relation to the ecology of solitary *Atilax*, and comparisons with sociable *Helogale* are made.

Introduction

POCOCK (1916) was the first to describe the external structure of the anal sac in *Atilax*. More recently interest in mongoose scent glands and their secretions has increased. GORMAN (1976, 1980) and GORMAN et al. (1974) have analysed the anal secretions of *Herpestes auropunctatus*, and HEFETZ et al. (1984) have shown that *Herpestes ichneumon* exhibits sex specificity with regard to its anal gland secretions. In addition marking behaviour has been studied in *Helogale undulata rufula* (RASA 1973) and *Suricata suricatta* (MORAN and SORENSSEN 1980). HEDIGER (1949), FIEDLER (1957), MICHAELIS (1972) and EWER (1973) have described some of the marking behaviour in a variety of herpestines, including *Atilax*.

The current study describes in detail marking behaviour in captive water mongooses. An attempt is made to interpret the meaning of the various marking behaviour patterns and to compare these with patterns in other herpestines.

Material and methods

Eight mongooses (three males and five females) were held captive in outdoor enclosures. Details regarding their housing are presented in BAKER and MEESTER (1986). Observations were made from an observation hide one metre distant from the cages. Marking sequences were either recorded on detailed check sheets or filmed using a National VHS portable video system. Frequency of marking events was analysed for each hour of observation. Sequence analysis was carried out with the aid of transition matrices and flow diagrams were constructed (CHATFIELD and LEMON 1970; LEHNER 1979). A behaviour sequence was delimited by the initial approach to and withdrawal from the object to be marked.

Results

Four methods of depositing scent products were recorded, including defaecation, urination, anal dragging and cheek rubbing. Figure 1 shows the frequency of the different marking patterns. Allomarking was not observed and all marks were deposited on inanimate objects. However, hand-raised mongooses did mark their 'human parent'.

Defaecation

In 15 different 24-hour periods defaecation occurred twice per individual animal. Mongooses tended to defaecate soon after becoming active in the early evening (between 17h30 and 19h30) and then again in the early hours of the morning (between 05h00 and 06h30) before retiring for the day. Scats were always deposited on specific scat sites or middens. In six out of the eight mongoose enclosures the middens were located at the furthest point from the nestbox, while in the remaining two enclosures the middens were positioned close to the nest site. All defaecation sites were located at ground level and scats were never deposited over tree trunks or on rocks. When two or more animals were housed together, a common midden was used. Once the particular site for defaecation was chosen there was never any change in its location.

Defaecation postures usually involved a simple squat. The tail position was characteristic, extending straight backwards with a slight upward curve along its length. Mongooses often circled a few times before settling to defaecate.

Urination

Urination frequencies varied from zero to 5 times per hour ($\bar{x}=0.55$, $n=158$). Urination frequencies were significantly higher when mongooses were housed alone than when they shared an enclosure with a conspecific ($d=2.47$, $0.02 > p > 0.01$). Urination sites varied and, unlike scat sites, different parts of the enclosures were used, although some sites were preferentially marked such as small rocks, the midden and logs.

Urination was usually performed in a squatting position with the base of the tail positioned slightly higher than during defaecation. Male mongooses regularly lifted a hind leg when urinating, and on occasion females were also noted to use the leg lift. When using the leg lift position the mongooses were apparently not aiming to increase the height of the urine mark, as they did not always lift their legs next to a vertical object.

Anal dragging

Frequency of anal marking varied from zero through 21 times per hour ($\bar{x}=1.96$, $n=143$). The presence of known conspecifics had no significant effect on the rate of anal dragging ($d=0.09$, $p>0.1$). During the breeding season it was found that while there was no significant difference in anal marking frequency in males ($d=1.32$, $p>0.1$) there was a significant difference in females ($d=4.02$, $0.0001 > p > 0.00001$) with more marking exhibited during non-breeding. Anal scent was deposited on small rocks, nest boxes, tree stumps and tunnels within the enclosures. In time it was possible to locate anal marking sites visually as a result of discolouration of the marked object, as more and more layers of scent were deposited.

The anal drag was made by depressing the opened anal sac onto an object, as was described in EWER (1973). The use of the handstand position as recorded by HEDIGER (1949) and EWER (1973) was observed only three times during this study. On all occasions the mongoose concerned marked the upright walls of the nestbox after introduction to a new enclosure. The substance that was deposited had an oily consistency and was black when initially deposited. As time elapsed and the amount of secretion built up as a result of repeated marking activity, the deposit became creamy. On occasion the mongooses forcibly ejected anal fluid from the anal sacs, usually when startled or in stressful situations. This fluid was black, strong-smelling and extremely volatile. Initially the odour was overpowering, but over a period of 24 h it dissipated and was noticeable only if the deposit was closely investigated. After three days the smell was no longer distinguishable by the observer.

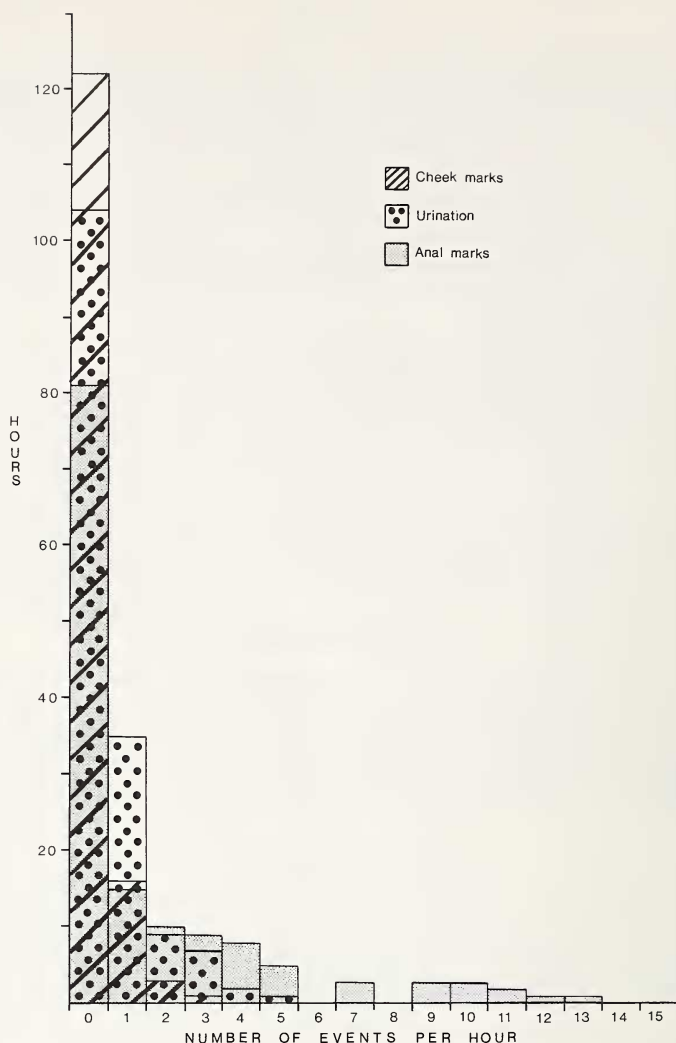


Fig. 1. Frequency of scent marking events in *Atilax*

Cheek rubbing

Cheek rubbing frequency varied from zero through three times per hour ($\bar{x} = 0.17$, $n = 142$). Frequency of cheek rubbing was significantly higher in the presence of known conspecifics ($d = 2.89$, $0.01 > p > 0.001$). During the breeding season females marked significantly more than during the non-breeding season ($d = 3.31$, $0.001 > p > 0.0001$), while in males no significant difference was found ($d = 0.9$, $p > 0.1$). The most commonly rubbed objects included the entrance to the nestbox, tree stumps and tunnels.

Cheek rubbing involved slowly wiping the sides of the head, from the corners of the mouth to the base of the ear pinnae, against an object. The secretion was never visible and the marked object bore no humanly-noticeable smell. However, the cheeks of the mongooses did have a pleasant honey-like odour. Figure 2 shows the sequences of behaviour patterns followed during glandular marking. Twelve transitions are shown,

indicating that the most common actions involved initially smelling the object to be marked, followed by either cheek or anal marking. The observed transition matrix was significantly different from a random distribution, $\chi^2 = 171.23$, d. f. = 16, $p < 0.001$. Mean duration of sequences was 11.61 sec, $n = 40$, $SD = 9.72$.

Discussion

The most frequent scent marking pattern used by *Atilax* is anal marking, followed by urination, cheek marking and then defaecation.

Clearly the amount of faecal and urinary material produced by a mongoose is dependent on its dietary intake. This may affect the frequency of defaecation and urination. In a captive environment, animals receive a constant and usually abundant supply of nutrients, so that the results reported here in respect of these two functions may bear little resemblance to the situation in naturally occurring *Atilax*. However, urination appears to serve not only as a means of excretion but also as a marking method. This is demonstrated by the high frequency of this activity, and the fact that only a few drops of fluid need be produced at a time.

The use of middens by carnivores is widespread (MACDONALD 1980). While middens in this study were never located on rocks, middens in the field are regularly found on rocky outcrops and bare expanses of rock as well as on sandy river banks. The lack of rock use by captive animals probably resulted from the absence of suitably large rocky surfaces. In *Atilax* midden use may be the most efficient method of information dissemination, regarding the inhabitants of a particular area. If, as EWER (1973) suggests, the faeces are coated with anal gland secretions as they pass out of the body, the scats become the calling card of that particular individual. GORMAN (1976) has shown that individual *Herpestes auro-punctatus* can recognize the anal gland secretions of particular conspecifics, and HEFETZ et al. (1984) have shown that *Herpestes ichneumon* males produce an anal scent component that is specific to their sex. RASA (1973) has also shown that dwarf mongoose scats bear the identity of the individual but that the identifying scent of faeces does not persist for long periods. If we are to assume that the same characteristics of faecal material apply to water mongooses then the importance of regular use of the same middens becomes apparent; by continuously using the same midden the scent of an animal is renewed regularly enough to inform other conspecifics of its presence.

The infrequent use recorded during this study of the handstand position in anal scent deposition may result from an insufficient number of appropriate upright marking posts. Further, as handstand marking was performed only when a mongoose was introduced to a new enclosure, it may be concluded that handstand marking is used only in those circumstances when the mongooses are highly motivated to mark.

Although cheek glands have not been anatomically described for this species, their presence is indicated on behavioural grounds both here and elsewhere (ZANNIER 1965; RASA 1973).

The marking sequences show a clear relationship between cheek marking and sniffing. As cheek marking was usually (50.7 % of the time) preceded by sniffing, it seems that the mongooses initially ascertained the status of the previous mark before either renewing their

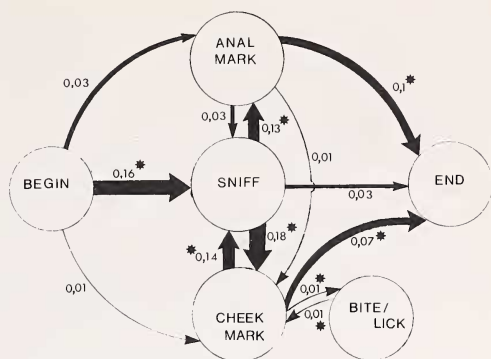


Fig. 2. Flow diagram showing the sequence of behavioural events during scent marking by *Atilax*. * Transitions above expected values

own or covering that of a conspecific. Most cheek marking behaviour (96 %) occurred when mongooses were housed with a conspecific of the opposite sex during the breeding season. During these times levels of agonistic behaviour were high and 71.4 % of the cheek marking episodes were carried out by females. If we assume that cheek marking carries a message of excitement/threat as in dwarf mongooses (RASA 1973), then the incidence of cheek marking during premating encounters is understandable, as during this period the female wards off and avoids the male. Only when she is ready to copulate does she cease cheek marking and entirely submit to her mate's demands.

In *Helogale* (RASA 1973) cheek marking is preceded by sniffing 71.2 % of the time, while anal marking is shown to mainly follow cheek marking. In *Atilax*, on the other hand, anal marking was preceded by sniffing 37.3 % of the time and never followed cheek marking. In addition *Atilax* preceded most marking sequences by sniffing (88 % of the time), indicating the importance of scent marking in their communication.

RASA (1973) has shown that cheek marks in *Helogale* have a brief effective period when compared with anal marks. In view of the sociability of dwarf mongooses, based on kinship and the concomitant need to maintain cohesion in the group, cheek marks may play a vital role in dissuading potential conspecific intruders from attempting to join the group, and it is therefore essential to precede most marking bouts with cheek marks. RASA (pers. comm.) indicates that cheek marking plays no role in establishing and maintaining rank within the family group.

For solitary *Atilax* a situation in which conspecifics would want to become part of a group does not arise, and hence cheek marking takes on a less significant role. However anal marking reaches far more significance when the need to advertise their identity to potential mates is considered. This is supported by the higher frequencies of anal marking when compared with cheek marking.

Interestingly, licking follows only anal marking in *Helogale* (RASA 1973) while in *Atilax* licking followed only cheek marking. RASA (1973) suggests that the mongooses occasionally lick anal secretions because of the general interest engendered by these secretions as well as their lack of threat connotation. In *Atilax* the cheek marks that were licked belonged to the owner and licking always immediately followed the cheek mark. In these cases licking may serve to reassure the mongoose of the intended threatening message.

When water mongooses were presented with a strong-smelling compound such as a deodorant or insecticide they frantically cheek-marked the object, rather than anal-marked it. In these circumstances (which are clearly unlikely to occur within the natural environment) cheek marking may have no threat connotation, and is more likely to be released by high excitation levels.

In general there was an even distribution of anal marking regardless of the presence of conspecifics, although 58 % of marking sequences occurred when conspecifics were present. Considering the identifying function of anal marking it is to be expected that in the natural environment it should occur more regularly as it would inform conspecifics of their presence.

The major sources of contact with conspecific water mongooses would be along feeding routes and at middens, and it is for this reason that anal scent is important as discussed earlier. To be able to establish the most recent visit to a midden by a conspecific would convey information regarding potential mates in the area. This is supported by the significant difference in marking frequency in females during the breeding season. In sociable mongooses the use of middens is likely to play a less crucial role with regard to breeding, as the members of the group are in constant contact anyway.

Stoats, like water mongooses, are solitary animals. ERLINGE et al. (1982) has shown that dominance in these mustelids is conveyed by increased marking levels and that subordinate animals attempt to avoid or escape from the dominant partner. Water mongooses exhibited similar behaviour patterns when housed in pairs during the breeding season, in that